Slopes," was planned and the project results were to be incorporated into the final product of NCHRP Project 22-21. An analysis performed in the 1970's indicated that most guardrails did not perform well when placed on 6:1 and steeper slopes. Since that time, the vehicle fleet has changed dramatically with a significant increase in the popularity of light trucks and sport utility vehicles. In addition, there has been a significant change in the design of roadside barriers in recent decades. It is unclear how these changes affect the behavior of longitudinal barriers placed on sloped terrain. Information from the NHTSA FARS database indicated that some cross-median crashes occurred where median barriers were in place. A full-scale crash test also showed that a passenger vehicle could penetrate a CMB on the backside of a depressed median. With the dramatic increase in the use of CMBs in depressed medians, a more detailed study on the performance of barriers in depressed medians is needed to achieve acceptable safety performance.

During the 2007 Summer Meeting of the TRB AFB20 (Committee on Roadside Safety Design), placement of CMBs on sloped medians was considered one of the most important and urgent issues for roadside safety research. Research was suggested to consider the safety and maintenance aspects, impact angles, impact speeds, critical impact points, cable heights and spacing, post spacing and deflections, and soil conditions.

2.2 Crash Modeling and Simulations

Macherle (2003) provided a bibliography of 271 references published from 1998 to 2002 on crash simulations using FEA and impact-induced injuries. This bibliography categorized the references into four different topic areas: 1) crash and impact simulations without occupants; 2) impact-induced injuries; 3) human surrogates; and 4) injury protection. The first topic area included crashworthiness of aircrafts, helicopters, automobiles, and vehicle rail structures. The second area of research utilized two major types of models for humans, crash dummies and real human bodies. Research topics in this area were mainly on biomechanics and impact analyses for various human injuries. Topics on human surrogates focused on the development of FE models of hybrid and other types of human dummies. These dummy models were used to obtain dynamic responses of human bodies during impacts, which were difficult to measure experimentally. In the fourth area, FE modeling was utilized to analyze and simulate injury protection systems such as seat belts, air bags, and collapsible structures to reduce serious and fatal injuries. The references included in Mackerle's bibliography are generally useful to the work on FE crash simulations; however, only a few references under injury protection are related to roadside safety and none is related to CMB simulations.

Most of the publically available FE models of vehicles and roadside safety structures were developed at the NCAC. Since the 1990's, significant effort has been put into the development of FE models that are available as LS-DYNA input files (NCAC web1). A list of references of these modeling efforts and simulation work performed at NCAC is also available (NCAC web2). The modeling and simulation efforts at NCAC can be found in several representative studies. Marzougui et al. (2000) developed the FE model